

Frequently Asked Questions: Results of a NIOSH Study of Former Microelectronics and Business Machines Manufacturing Workers



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Questions Related to How the Study Was Done

1. Why did we mainly look at deaths and not diagnoses?

Studies of workers in the United States commonly look at deaths because this can be done using existing records. In these studies, deaths are identified by linking a list of workers with national death data. In contrast, national data that can be used to identify workers who were diagnosed with cancer or non-fatal diseases do not exist in the United States. Cancer diagnoses can be identified from state cancer registries, but former workers may have moved to other states.

2. Why did we look at testicular cancer incidence (diagnosis) and not incidence of all cancers?

Among the cancers of primary concern, testicular cancer was the only cancer that could not be adequately evaluated by looking at cancer deaths (there were only two deaths from this outcome).

3. Why did we compare disease outcomes between various groups?

We did this to examine the potential link between job exposure and health. If a disease occurs much more frequently among workers than the general population, it suggests that job exposures may have played a role. Also, if a disease occurs more frequently among workers with more potential exposure than for those with less potential exposure, job exposures may have played a role.

4. Why did we compare former workers to the general public?

We did this to see if workers had higher rates of deaths or higher rates of testicular cancer diagnosis than the general public of the United States or New York State (excluding New York City). Studies of workers often find that workers are healthier than the general population; this “healthy worker effect” is due to factors such as access to health insurance, screening physicals for incoming employees, and people who are too ill to work not entering the workforce. This effect tends to be stronger for non-cancer outcomes than for cancers.

5. How did we compare former workers to the general public?

First, we grouped all causes of death into over 100 cause of death categories. Then, we compared the rates for each cause of death category and testicular cancer diagnosis in workers with how frequently they occur in the general population. These comparisons were done separately for men and women because job exposures and health risks can be different for men and women. We also separated workers by pay code. This was done because hourly-wage workers were more likely to be exposed to the chemicals than salaried workers and because hourly and salaried workers may differ in other ways.

6. Why did we compare former workers with more exposure to those with less exposure?

We wanted to see if workers with more potential exposure to certain chemicals had higher rates of death from the diseases of primary concern compared to workers with less exposure.

We also compared rates of death based on how long people worked in a subset of manufacturing buildings. This was done because we could not assess exposures to all chemicals used at the facility and because former workers expressed concerns about having worked in certain buildings. Specifically, we compared people who worked in buildings 18, 41, 46, 47, 53, 57, and 259 for longer periods of time to those who worked there for shorter periods of time or never. In both the chemical and building comparisons, differences between men and women as well as salaried and hourly-wage workers were taken into account.

7. Why didn't we interview workers or get their medical charts?

It is extremely important to have the same information for all workers. All information used to construct employees' work histories came from IBM human resources databases. While medical charts may contain important detailed information, they do not contain the same information for all workers. Instead, we obtained information about health outcomes from national and state vital record sources and state cancer registries. These are designed to capture similar information for everyone, regardless of employment status or location.

We did not interview former employees because in order to have the same information for all workers, we would have needed to contact every former employee. It would have been very difficult and costly to locate, contact, and administer a survey to all former employees who were eligible for the study. It is unlikely that all of those workers would be located.

Questions Related to Exposure Estimates

8. How was each person's potential exposure to chemicals estimated from his/her work history records?

In our study, we used existing chemical and work process records. We first identified whether work in each department for each year since 1969 involved exposure to the following specific chemicals and groups of chemicals:

Specific chemicals:

- TCE (trichloroethylene)
- PCE (perchloroethylene, also called tetrachloroethylene)
- lead
- methylene chloride

Chemical groups:

- acids and bases (including hydrochloric acid and sodium hydroxide)
- chlorinated hydrocarbons (including TCE, PCE, methylene chloride, and methyl chloroform)
- other hydrocarbons (includes isopropyl alcohol, other alcohols, ketones, aldehydes, glycol ethers, and oils; aromatic hydrocarbons and chlorofluorocarbons were not included)

Next, we linked these data to each person's work history to calculate how long they worked in departments involving potential exposure to these chemicals. We then converted this length of time into an exposure score. The exposure score is an estimate of how much job exposure a person may have had and is used to compare workers by their potential for exposure. The higher the score, the more we think the person was exposed. For each worker, the exposure score was calculated by giving less weight to time worked in departments where chemicals were used intermittently, and less weight to time in administrative or clerical positions since they were less likely to involve direct chemical exposure. Someone who worked for many years in a department involving hands-on use of a specific chemical would have a much higher exposure score for that chemical than someone who worked briefly as a secretary in a department that intermittently used that chemical.

Former workers and company representatives provided valuable input in this process.

9. What records did we use to assess chemical exposure?

Our study's assessment of chemical exposure needed data on chemicals used at the Endicott site for the entire study period (1969 through 2001). There was no one source of data that provided all the information we needed to do our study. Therefore, we had to pull information from multiple sources:

Source of Data	Type of Data	Years
IBM	Exposure-related data in the Industrial Hygiene (IH) air sample database	1980-2001
IBM	Exposure-related data in microfiche and paper documents from IH department	1974-2001
IBM	Exposure-related data in Environmental Impact Statements	1974-1980 1985-2001
IBM	Department codes Department codes and names in employment records	1969-1974 1975-2001
IBM	Position codes Position codes and names in employment records	1969-1974 1975-2001
Agency for Toxic Substances and Disease Registry (ATSDR)	Chemical use data in a historical outdoor air emissions report for the site	1965-1980

10. Did you use the estimates of facility chemical emissions produced by ATSDR?

No, we did not. Air emissions estimates were not important for our study. We used the ATSDR report for the data it contained about chemicals used at the Endicott site in the early years of our study. This information was especially important for the years prior to 1974 when IBM sources of such data were unavailable. Other environmental reports of chemical emissions at the facility for later years were not sought or needed, since the detailed occupational data we needed concerning department use of chemicals were available in the IBM records sources.

11. Why did we create exposure scores instead of estimating actual levels of exposure?

We evaluated exposures in almost 3,000 departments during each year each department existed. We did not find direct measurements of exposure levels for many of the departments which used chemicals or from the earliest years of the study. We also did not find enough other related information to estimate what individual workers' exposure levels might have been.

12. How did we assess time spent working in certain buildings?

The company records did not indicate which building each worker worked in. We used information we gained about certain process building-department relationships to associate departments with buildings. Then, we used workers' department history records to estimate how long each employee worked in buildings 18, 41, 46, 47, 53, 57, and 259.

13. Did we consider soil vapor intrusion and other sources of environmental contamination at the facility or at each person's home?

Our study indirectly considered vapor intrusion at the facility but did not consider any residential environmental contamination. We focused on process-related job exposures to the former workers at the worksite. However, our assessment considered all information in the company records obtained, which included some chemical monitoring results for samples collected in the building areas. These samples are typically collected to evaluate the presence of chemicals in the air due to nearby process equipment, but would have included contributions from any sources including vapor intrusion, if present. It was not feasible to consider these exposures at the facility in a more detailed way. We did not have enough information about how soil vapor intrusion varied over time within buildings at the facility or enough detail about where workers were located within buildings. We did not consider these exposures at workers' homes because our study focused on work-related chemical exposure. Reports from environmental studies of the community can be found at www.health.ny.gov/environmental/investigations/broome/.

Questions Related to the Findings

14. What was the study population like?

The study population was relatively young, with 83% of the former workers in the study still living. Of the 34,494 people in the study, 4,092 men and 874 women had died.

The average length of employment at the facility during the study period was about eight years. Over half of the salaried workers and about one-fourth of hourly-wage workers had worked at other facilities owned by the company.

About 41 % of the men and 10 % of the women had worked at the facility before 1969 when the study period began. Records were inadequate to assess job exposures before 1969 for these workers, and thus, they probably had more exposure than we estimated.

15. What did we find in terms of exposures?

Based on our estimates:

- 70% of the former workers in the study were potentially exposed to chemicals at the facility.
- 51% were potentially exposed to one of the specific chemicals or chemical groups that we assessed in the study.
- As expected, hourly-wage workers were more likely to be exposed to the chemicals we assessed than salaried workers. Men were slightly more likely to be exposed to the chemicals we assessed than women.
- Few workers were exposed to PCE or TCE compared to the other chemicals we assessed. Only 12% were exposed to PCE and 9% to TCE.
- The highest exposure scores for TCE were associated with circuit board manufacturing work prior to 1985. The highest exposure scores for PCE were associated with metalized ceramic substrate manufacturing work from 1974 to 1999.
- The most common exposure was to a broad group of hydrocarbons which excluded chlorinated and aromatic hydrocarbons and chlorofluorocarbons. This broad chemical group included isopropyl alcohol, which was commonly used as a circuit board cleaner, and a wide variety of other chemicals.

16. What are the main study findings?

The frequency of most causes of death (including most cancers) was not increased. However, we did find a few that were more frequent than expected. Of the many outcomes we evaluated:

- Rectal cancer, non-Hodgkin lymphoma, mesothelioma, pleural cancer, and testicular cancer occurred at higher rates in some groups of workers than would be expected from the general population.
- Chronic Obstructive Pulmonary Disease (COPD), melanoma, leukemia and chronic non-malignant diseases of the nervous system were relatively more common among those who worked in certain buildings for longer periods of time or had more potential job exposure to certain chemicals.

These findings could be due to job exposures, other factors we could not assess in this study, or chance. Among the factors we could not assess are family disease history, job exposures at the facility before 1969, job exposures at other worksites, environmental chemical exposures, and smoking.

17. How do other studies compare with our results?

Our findings can be compared to results of earlier studies that looked at causes of death in workers at this facility or across the company's facilities. These earlier studies found elevations for lymphoma and non-malignant nervous system diseases, including multiple sclerosis, amyotrophic lateral sclerosis (ALS), and Parkinson's disease. We found more deaths from non-Hodgkin lymphoma, a specific type of lymphoma, among hourly-wage men than expected. The elevation in non-malignant nervous system diseases in one of the earlier studies is echoed to some extent in our study. Data from our study suggest that deaths from ALS in hourly-wage workers and from Parkinson's disease in salaried men were more frequent than expected, although these findings are less certain than the main findings of our study described above. Deaths from multiple sclerosis were not elevated. We also found that workers with more exposure to PCE were more likely to die of chronic non-malignant diseases of the nervous system as a group.

Previous studies of Endicott residents found increases in kidney cancer among residents in the area primarily contaminated with TCE, increases in testicular cancer among residents in the area primarily contaminated with PCE, and, to a lesser extent, increases in lung cancer among residents of both areas. Data from our study suggest that workers with more exposure to TCE may be more likely to die of kidney cancer, but this result is less certain than the main findings of our study. Testicular cancer was more common among salaried males than we would expect, but was not associated with PCE exposure. Deaths from lung cancer were less common than expected in workers, and were not associated with any of the specific chemicals or chemical groups that we assessed.

18. How was the NIOSH study different from the 2008 study (Clapp and Hoffman, 2008) of this facility?

NIOSH looked at the rates of death in former workers and the association between rates of death and chemical exposures. In the 2008 Clapp and Hoffman study, the investigators only had access to the death records. They did not have access to work history or exposure records.

19. Did TCE cause cancer among former workers?

We cannot tell from this study whether TCE caused cancer among former workers. From other studies, we now know that TCE can cause kidney cancer. Our study suggests that former workers with more exposure to TCE may be more likely to die from kidney cancer and leukemia (except chronic lymphocytic leukemia) and may be more likely to be diagnosed with testicular cancer. However, these results for kidney cancer and testicular cancer are less certain than the result for leukemia and the other main findings of the study. We cannot tell if these results are truly due to TCE exposure, other factors or chance.

20. Does the study shed light on whether environmental TCE contamination caused health effects in the community?

We know there is concern about environmental contamination within the community surrounding the worksite. We also know that there was hope that our study would be able to shed light on whether environmental TCE exposures could be linked to health outcomes. Job exposures at this site were diverse and were very different from the environmental exposures. For these reasons, we cannot apply our results to the surrounding community.

21. I am a former worker, and I have one of the diseases that were more common among some workers. Does this mean that my work at the facility caused my disease?

This study cannot determine if an individual's cancer is caused by their work at the facility. In addition to the job exposures you may have encountered at work, there are other factors that may influence whether or not you may have developed a particular disease, such as:

- Personal characteristics such as age, sex, and race
- Family history of cancer
- Diet and personal habits such as cigarette smoking and alcohol consumption
- The presence of certain medical conditions
- Exposure to agents that cause cancer outside the workplace

Miscellaneous Questions

22. Have living workers been studied? Are there plans to do this in the future?

Our study looked at testicular cancer cases, including cases in living workers. The birth defects part of our study will report results for workers' children, most of whom are also living.

The NYSDOH/ATSDR environmental study of Endicott area residents, a group that included some workers, evaluated birth defects, cancer cases of all types in adults, as well as cancers in children. That study used records to look at cancer cases, rather than deaths. Many in the study were living, as were the children born with birth defects.

We do not know of any plans for additional analyses of living workers.

23. How can the study population be described as young, when many workers started at the facility a long time ago?

Because of records limitations, we had to set the study begin date to January 1, 1969. Any worker whose employment at IBM-Endicott ended before that date was excluded from the study. This exclusion lowers the average age of the study population.

24. What are the study strengths?

The study has the following strengths:

- Study population was relatively large
- Study provides knowledge about computer manufacturing workers
- Obtained input from community and workers during study planning and conduct

25. Why did the study take so long?

These types of studies typically take a number of years because of the time needed to obtain and evaluate the large number of records involved. In this study, we evaluated chemical use for 27,807 department-year combinations. We also pulled together information from several different computer databases and determined how to handle conflicting and missing information. After we analyzed, interpreted, and wrote up the findings, the paper underwent a rigorous review within NIOSH and at other institutions to verify that results are unbiased and sound. This all had to occur before the results could be published and released.

26. How long does it take for job-related health outcomes to occur? How is this dealt with in the study analyses?

The time from when a disease process begins to when it is diagnosed varies greatly. It is commonly thought that it takes about 10 years for most cancers to develop and be detected. We accounted for this 10-year period between exposures and health outcomes when we assessed whether specific cancers were relatively more frequent among workers with more exposure to certain chemicals. The only exception is that we used a two-year period for leukemia (excluding CLL), as most leukemias are thought to be diagnosed more quickly after exposures. We did not account for this when we compared workers to the general population.

27. Could the study be updated in the future to shed more light on whether exposure to TCE or other chemicals is related to health problems among former workers?

The study could be updated in the future. However, questions about the role of job exposures will likely remain because of the limitations of the data.

28. Was this a TCE study?

No, though we did what we could to assess the possible effects of TCE because we knew it was important to the community. Though TCE was used at the facility, there were no records of TCE levels during the time period when it was widely used (before 1974). For this reason, we were only able to look at TCE in a limited way. Workers were also exposed to many other chemicals, which made it difficult to evaluate the health effects of TCE alone.

29. When were TCE and PCE used?

ATSDR's historical emissions report showed large quantities of TCE were used at Endicott during the last half of the 1960s and early 1970s. We know TCE use was reduced by 1974 since we noted very limited use of TCE based on the IBM industrial hygiene files available. Based on these files, TCE was last used in 1985. PCE use was noted during most of the study years and was mainly associated with substrate manufacture, which was probably highest in the late 1970s and 1980s. PCE use declined in the 1990s, probably due to changes in substrate manufacturing volume, and to regulatory concerns, since PCE is a chlorinated solvent. Substrate manufacture ended in 2000.

Generally, companies look for substitute chemicals when new information emerges on chemical hazards and when workplace or environmental regulatory limits are instituted or reduced. These changes often require costly process and engineering improvements and waste management controls and practices. It is often advantageous to phase out, or limit, the use of a chemical if it cannot be replaced.

30. How were emergency services and maintenance personnel incorporated into the study? Were they assigned to a building?

Yes, emergency services and maintenance personnel may have been assigned to one or more buildings depending on their department and year. These personnel were handled in the same way as all others in the exposure assessment. For each year a department existed, we recorded data identifying chemicals used, and we also recorded the building(s) where the work occurred. Some of the many maintenance departments were associated with the seven process buildings in our study and some were not. Among those maintenance departments which were associated with process buildings, usually one or two process

buildings were identified. Emergency services departments were not often identified by department name. When department-years containing emergency services, maintenance or any other personnel were identified with one of the seven buildings assessed in this study, the department-year members were assigned to that building(s). When records for a particular work history period did not support linking a department to a building, no building assignment was made for that work history period.

31. Did including office workers and other workers who had little chemical exposure influence the results?

We conducted some supplemental analyses that excluded workers thought to be unexposed to chemicals and did not find major differences in the results. Including these workers allowed us to compare workers with relatively more potential exposure to workers with relatively less potential exposure.

32. Does the ongoing birth defects study include miscarriages?

No, it does not include miscarriages. The birth defects study is limited to defects in live-born infants diagnosed with a congenital malformation by age two.

Because many miscarriages occur before a woman knows she is pregnant, miscarriages are best studied by identifying a group of women and tracking their reproductive cycles and outcomes as they occur. Our study looks at work and health outcomes that happened in the past based on existing records and therefore cannot assess miscarriages.

33. Can anything else be done to study some of the chronic, non-malignant nervous system diseases like Parkinson's disease and amyotrophic lateral sclerosis (ALS)?

Our study found that some groups of workers appear to be more likely to develop certain non-malignant diseases of the nervous system such as ALS and Parkinson's disease. Questions remain about whether these increases are related to job exposures at IBM-Endicott. Unfortunately, we do not have a good way to look at Parkinson's disease more closely among former IBM-Endicott workers. Looking at deaths is not a very good way to study Parkinson's disease, because this disease is often not listed on death certificates. Identifying former workers living with Parkinson's disease would also be difficult because a national registry of people living with Parkinson's disease does not currently exist in the United States, and many former workers have moved to other cities and states.

Updating this study in about 10 years could provide a more certain answer about whether ALS is more common among hourly workers than the general population. If you have ALS, or know someone who does, visit www.cdc.gov/als or call ATSDR at 1-800-232-4636 to learn more about the National ALS Registry. This national registry was established in 2010 to help scientists learn more about this disease.

34. Do the study findings apply to workers outside of this worksite?

No, the results of the study are not generalizable outside of this worksite because of the diverse facility exposures and record limitations. IBM-Endicott manufactured many different products over the years. The processes and chemicals used varied across the facility and changed over time. Some products were unrelated to the electronics industry (e.g. guns). IBM did not make computer chips in Endicott, so a study of the facility would not provide information about this or other aspects of the industry that involve processes not performed in Endicott. These factors make it difficult to generalize the findings to other facilities engaged in microelectronics or business machine production.

Also, because of records limitations, we could not estimate levels of exposure for each worker. Therefore, we could not evaluate potential links between exposure to a certain amount of a specific chemical with risk of a specific health outcome. That type of numerical data would be helpful for the results to be generalized to workers in other settings who use the same chemical.